Characterization of Uncertainty in Low Frequency Active Sonar

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LONG-TERM GOALS

The goals of this project are to characterize and evaluate the effects of uncertainty on low frequency impulsive active sonars of the type exemplified by Distant Thunder (DT) or Extended Echo Ranging (EER). This project is a component of the UNITES effort aimed at (i) comprehending uncertainty in the ocean environment and characterizing its impact on tactical sonar performance, and (ii) providing the Navy with guidance for understanding sonar performance in the littoral.

OBJECTIVES

Performance prediction models are used to characterize expected operational capabilities of sonars. The signal-to-interference ratio (SIR) environmentally-induced probability density function (SIRE-PDF) is the distribution of the difference between measured and modeled SIR, and describes the predictive capability of the present model (that is, for specific location and time) with respect to actual performance. Thus, the SIRE-PDF accounts for the inherent unmodeled variability of the environment and is a probabilistic description of intrinsic environmental uncertainty. The focus of this effort is to formulate and evaluate significant examples of SIRE-PDF for low frequency impulsive active sonars

APPROACH

To establish the interference component of the SIRE-PDF, a data-based approach will be followed using environmentally well characterized data selected from the Area Characterization Test III (ACT III) obtained under the DARPA Adverse Environments program in 1996 in an operationally significant area (Korea Strait). These data will be used to determine the distribution of the difference between measured and modeled reverberation or noise interference. To establish the signal component of the SIRE-PDF selected high signal-to-background target echoes from DT exercises (SHAREM 122, 126, 127, 130 and 136) since 1997 will be used. These data will be used to determine the distribution of the difference between measured and modeled target strength. The signal-to-interference EPDF can be constructed from the distributions of measured minus modeled signal and interference [1].

The initial work focuses on characterization of reverberation. Reverberation modeling uncertainty involves stochastic variability of reverberation scattering strength and of transmission loss to and from the scattering region, plus more systematic uncertainty involving spatial variations of scattering strength and transmission factor. These spatial variations can occur over range, azimuth, distance from the shore in continental shelf areas and source and/or receiver depth. Characteristically, for shallow water active sonar, bottom reverberation is the prevalent interference. The uncertainties under consideration are manifest in bottom scattering strength measurements. Recent bottom scattering

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14. ABSTRACT
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strength determinations [2] suggest a typical statistical variability in the determination of scattering strength of ±3-4 dB, with this uncertainty dominated by the variability in the transmission loss. To determine the interference SIRE-PDF, reverberation modeling can be accomplished using measurement-derived scattering strengths with appropriate propagation codes incorporating the most reliable geo-acoustic models. By further analyzing the reverberation data collected under the Adverse Environments program [2] the distribution of the difference between measured and modeled reverberation (reflecting the sources of variability described above) will be obtained. Selection of the data for analysis and definition of the procedure will be under the direction of Peter Cable (BBN); data processing will be under the direction of Jay Pulli (BBN) and will be performed by Zach Upton and Kathi Fuqua of BBN. The resulting SIRE-PDFs will be forwarded to OASIS, our colleagues in this effort, for further analysis under the direction of Philip Abbot.

WORK COMPLETED

The relevant ACT III data runs (containing reverberation and transmission loss run data) have been selected and the data tapes identified and located. To accommodate the inevitable changes in computers and operating systems that had occurred over the time from when the data were obtained, scripts to read the data tapes have been written and tested. The analysis procedure has been formulated and data processing, analysis and interpretation is ready to begin pending a planning meeting with OASIS (Philip Abbot)

RESULTS

The effort is in its initial phase and there are no technical results yet.

IMPACT/APPLICATIONS

There is a Fleet concern that performance prediction and tactical decision aids (TDA) are often not reliable because of the inherent uncertainty associated with the TDA inputs. The impact of the current work will be to identify the sources of uncertainty (whether from intrinsic variability or unknown end-to-end parameters) for low frequency broadband active sonars and to reduce, to the extent possible, the unknown to intrinsic variability. The application will be to TDA improvements for such systems as DT and IEER.

TRANSITIONS

There are no transitions yet, but the results of these studies, the SRI-PDFs for low frequency broadband active sonar will be used by our UNITES colleague Philip Abbot at OASIS in his investigation.

RELATED PROJECTS

This project is part of the UNITES project and is coordinated and linked with the other efforts under the UNITES team. Other related projects include the other programs under the ONR Code 32 Department Research Initiative (DRI) on the effect of acoustic environmental uncertainty on the performance of Navy systems. Reference to this program and these projects can be found at the following website: http://www.onr.navy.mil/sci_tech/chief/cuwg/default.htm

REFERENCES

1. A. Papoulis, *Probability, Random Variables and Stochastic Processes*, p 197, McGraw-Hill, NY, 1965

2. P.G. Cable, K.D. Frech, J.C. O'Conner and J.M. Steele, "Reverberation-Derived Shallow-Water Bottom Scattering Strength", IEEE Jour. Oceanic Eng **22**, 534-540 (1997)